

TAMPERE POLYTECHNIC  
University of Applied Sciences  
International Pulp and Paper Technology

Final thesis

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OPTIMISATION OF CUSTOMER ROLL QUALITY IN WINDING

Thesis supervisor  
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Tampere 2006

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M-real, Kirkniemi mill

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ABSTRACT

The subject of this thesis work was to optimise customer roll quality after modernisation of winders. In later parts of thesis work documenting effects of modernisation became main subject as good drive values were found.

In this work different winder types are studied and measuring methods introduced. Advantages of multistation winder on LWC paper became clear. Trial runs have been carried out to evaluate effects of modernisation and also to solve encountered problems. Mainly trial runs are made on multistation winder to study effect of different drive values with new roll cover and rider rolls.

## FOREWORD

I began doing this thesis work on January 2005. The work consists of written, more theoretical part and experimental part.

I want to thank my thesis supervisor for help and great patience. I want also thank Tommi Hevonoja and Jaakko Rintamäki who provided guidance in paper mill. Tero Rämä from Metso Järvenpää provided very important help in measuring techniques. Other mill staff also deserves thank for good cooperation and atmosphere. Special thanks go to important people of my life who have supported me.

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# **1. Introduction**

## **1.1 Background**

Winding is the final section in paper mill where customer roll quality can be influenced, which means winding should be done so it fulfils customer expectations. Increasing customer roll diameter set new challenges for winding equipment and methods, also paper quality is all the time more important when bigger rolls are made at high production speed.

## **1.2 Objects**

The original object for this final thesis was optimization of three winders at A-factory at Kirkniemi paper mill. These three winders slit parent reels from two paper machines into customer reels. At the later part of modernisation it was decided to change objects of this final thesis more to concentrating on documenting progress made in two investments made. On PL3 larger rebuilt was done when it had hard cylinders replaced with cylinders with soft roll covers. In same rebuild also conventional rider roll units were replaced with belted ones. The other investment was replacing hard rider roll with soft covered one on PL1.

## **1.3 Kirkniemi Mill**

Kirkniemi paper mill started 1966 when PM1 started as newsprint machine, but soon 1968 it was changed to produce SC paper. It has been rebuilt twice in 1982 and 1994, in latter investment it was converted to produce film coated offset paper (FCO) PM2 started in 1972 producing LWC paper. PM2 was modernised in 1989 and began producing LWC coated with gypsum in 1990. PM1 and PM2 form “A-factory”. They share same machine width, which enables using all three winders for the combined production of two paper machines.

PM3 became operational in 1996. It produces two time coated MWC or fine papers. PM3 is located on separate building and is considerably larger machine than the older ones. Until 2006 speciality in PM3 products was utilization of aspen mechanical pulp in paper. The combined production of mill is over 700 000 tons of paper per year.

Production is divided so that PM1 and PM2 produce around 180 000 tons per year both and PM3 produces around 350 000 tons [6,12]

## **2. Winding**

The main mission for winder is to slit and reel parent rolls from paper machine to customer rolls that fulfil the required parameters. In printing and converting good runnability is essential. Roll quality must be good enough to withstand the stress caused by unwinding and printing. Beside actual converting processes roll should also be able to withstand stress from packing, storage and transportation. [1]

There are two main winder types used to produce desired winding result: Multistation winders and two drum winders. Both these two winder types have their advantages and disadvantages. Two drum winder has advantage from cheaper construction and shorter set change time. In normal situation two drum winder has considerably higher production capacity than multistation winder winding at equivalent speed.

Multistation winder is best suited for dense printing papers where two drum winder has its worst deficiencies. Construction of multistation winder allows better control over individual customer rolls than it is possible to achieve with two drum winder.

### ***2.1 Winder functions***

#### **2.1.1 Unwinding section**

Parent reel is usually placed to unwinding stand either by using crane or by using track leading to unwinding post. Unwind stand is equipped with electrical brake generator or with mechanical brake. The purpose of this braking system is to generate and maintain sufficient tension needed for web handling and for optimal winding result. Unwinding position can be manoeuvred sideways in order to get parent reel in correct position. There is also possibility to oscillate in order to reduce problems caused by paper thickness variation. In some cases unwinding stand allows also parent reel to be placed diagonally in order to even up tension variation between parent reels ends. This effect can also be achieved by diagonal placing of lead roll. [2]

### **2.1.2 Slitting**

Paper web has to be guided through the winder. This is done by using guide and lead rolls. Usually full width lead rolls are driven in order to maintain same speed with the paper web. Sectional lead rolls are usually undriven. [7]

Slitting is done by two rotating blades in each slitting unit. These blades slightly overlap. Only lower blade is driven while upper blade is undriven. Lower blade has larger diameter than upper blade. Slitting result can be controlled by altering amount of overlap and by changing cant angle. Sharpness of blades is also significant factor in slitting quality. [2]

Amount of overlap affects greatly to slitting result. Too large overlap causes dusting problems as it increases stretching of paper. Dusting is also partly caused by longer contact with upper blade. Due to these reasons overlap should be as small as possible without risking blades bypassing each others. In case of too small overlap blades bypass each others, which almost certainly causes web break.[4,6]



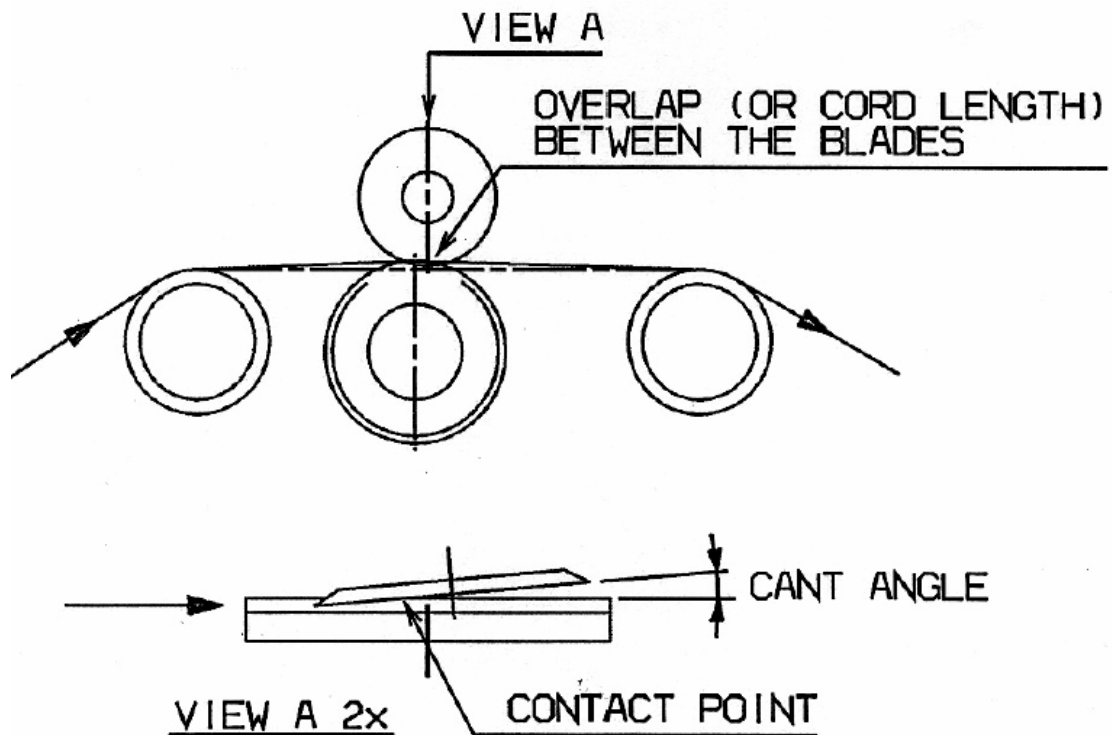


Figure 1. Tangential Shear slitting method [2]

### 2.1.3 Windup section

In windup section slit paper is wound up as customer reels. In this part are the main differences between two main types of winders I have studied in this thesis work. There are three main methods for winding. Possibility is to apply winding force to centre of the reel through core, to roll surface or with combination of these methods. Both winder types I have introduced in this work use winding force applied to roll surface. Exception to winding force used is heavy stations on PL2 and PL3 which can also use additional centre winding. Heavy station is normally used to exceptionally wide customer rolls.

## 2.2 Two drum winder

PL1 is two drum winder. This type is not very suitable for LWC-paper, but it is used for winding PM1 paper. The biggest limitation of two drum winder is nip load increase produced by the roll weight. Another problem is uneven rider roll load for

customer rolls, this is problem especially on very wide machines. The situation in many cases can be so that only few rolls support the whole rider roll load, due to uneven cross directional profile of the paper. This may cause corrugations.

The different parameters affecting roll buildup in two drum winder are combination of rider roll load, web tension and torque difference between two supporting drums. Other controllable values are winding speed, acceleration and deceleration.

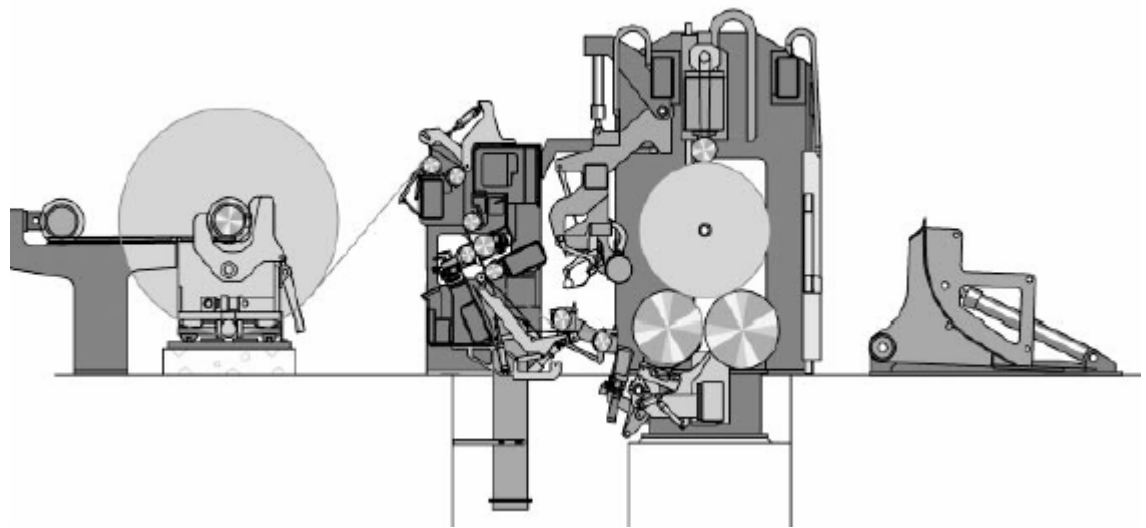


Figure 2. Two drum winder. [2]

### 2.2.1 Winding Force controlling methods

In Two drum winding nip load is combination of weight of the set and rider roll load. In the beginning of the winding the weight of paper roll isn't enough and rider roll defines the nip load. In the end rider roll is in many cases totally relieved, this is the case also in PL1.

To apply desired winding force to roll in two drum winder there is also possible to adjust torque differential between front drum or second drum and back drum which is also called first drum. These forces are in latter picture represented as  $M_1$  and  $M_2$ . Usually rear drum is speed controlled and front drum is torque controlled. Desired web tension is achieved with brake generator at unwind station. [3,10]

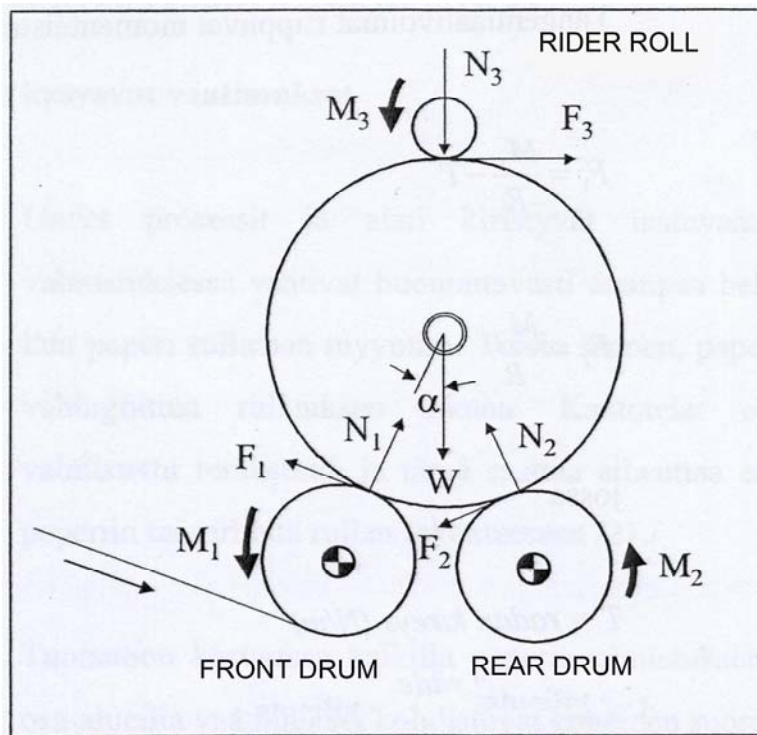


Figure 3. Winding forces on two drum winder [10]

### 2.2.2 Soft roll covers

In the end of the winding nip load tends to rise too big, due to all the time growing diameters of customer rolls. There are several applications which are designed to make this problem smaller. The one commonly used way is to cover rolls of two drum winder with softer polymer layer, this helps to reduce nip loads, but in many cases it isn't enough to solve the problem. The effect reducing nip load is result of widening of the nip caused by elastic roll cover. [2]

### 2.2.3 Relieving nip load by air pressure

Another way to reduce nip loads is to generate overpressure under paper roll during latter parts of winding. This system is called two drum winder with air relief. This method is best suited for porous paper grades, due to air entrapment problems which could be encountered with less porous paper grades. Paper grades that allow air pressure relieving as solution to high nip load issue are for example newsprint and uncoated woodfree. [2,4]

## 2.2.4 Belt supported two drum winder

In two drum winder concept there is also possibility to replace another drum with supporting belt. This allows nip loads to be fairly low as area supporting roll weight is larger than in other two drum winder types. Nip loads can be adjusted by altering belt tension, lower belt tension results lower nip load. In following picture the structure of belt supported two drum winder can be seen. During winding weight of the roll rests increasingly on belt as rolls diameter increases.[2,13]

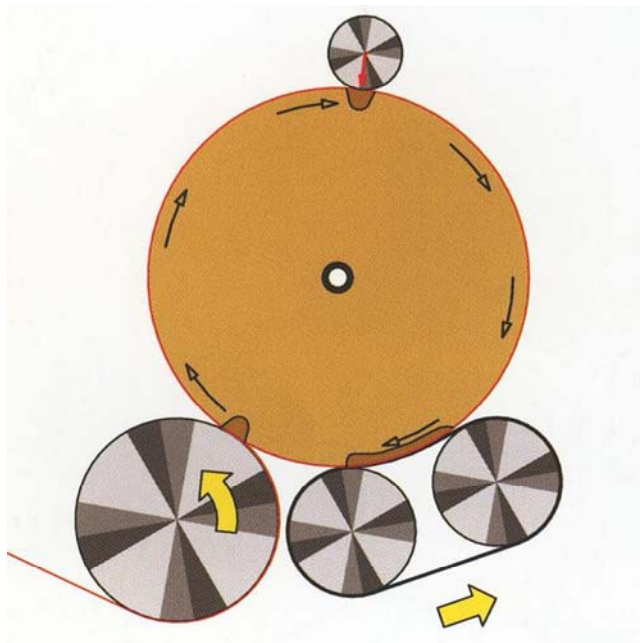


Figure 4. Belt supported two drum winder [13]

In belt supported winder nip load is not the main roll buildup tool, as there can be used high winding force together with low nip load. This combination helps to prevent nip-induced defects even with large roll diameters. Low nip load leads to the situation where winding force affects all customer rolls equally and results equal roll hardness through the whole web width. Belt supported two drum winder can be used to various paper grades, although it is not ideal choice for dense printing papers.

### **2.2.5 Variable geometry two drum winder**

Nip load can also be controlled by altering geometry of winding process. In this application front drum moves away from back drum as roll diameter grows. In this application all nips are soft and also drums have different diameter. Asymmetric design with pivoting rider roll beam reduces the risk of roll vibration. This design has been introduced to help using two drum winder with newsprint, SC and LWC Jumbo rolls, which are best suitable to be wind with multistation winder. [2]

### **2.2.6 Modernisation**

Before modernisation PL1 already had both front and back drum covered with soft nip cover. This improves winding result by lowering nip load caused by roll own weight in winding. During my thesis work the old rider roll was replaced with new rider having soft roll cover. Rider roll with soft roll cover had also been installed before, but there was a problem with cover material. In its previous assembly soft rider roll did help winding process before running into troubles.

The reason for this investment was to increase winding speeds, soft rider roll should lead to situation where higher speeds are possible with smaller dishing problem.

## **2.3 Multistation winder**

Development in winders has partly been directed to multistation winders due to difficulties encountered in winding large diameter rolls of high density thin paper grades with two drum winders. Nip load tends to rise uncontrollably during winding in two drum winders and one drum winder offers way to control nip loads more accurately.

Core supported winder is winder type which supports roll only from core ends. This puts very high demands for core strengths if roll diameter and weight grow very high. In producing small and light rolls these are still very useful pieces of equipment. The simplest form of core supported winder is a pure centre winder, there driving force is applied to the centre of a roll via the core. [16]

Multistation winders with core-, periphery-, and driven rider roll support are more modern technology than two drum winders. In this design rolls own weight doesn't have influence on nip load, nip load is determined by core support and rider roll support. [5]

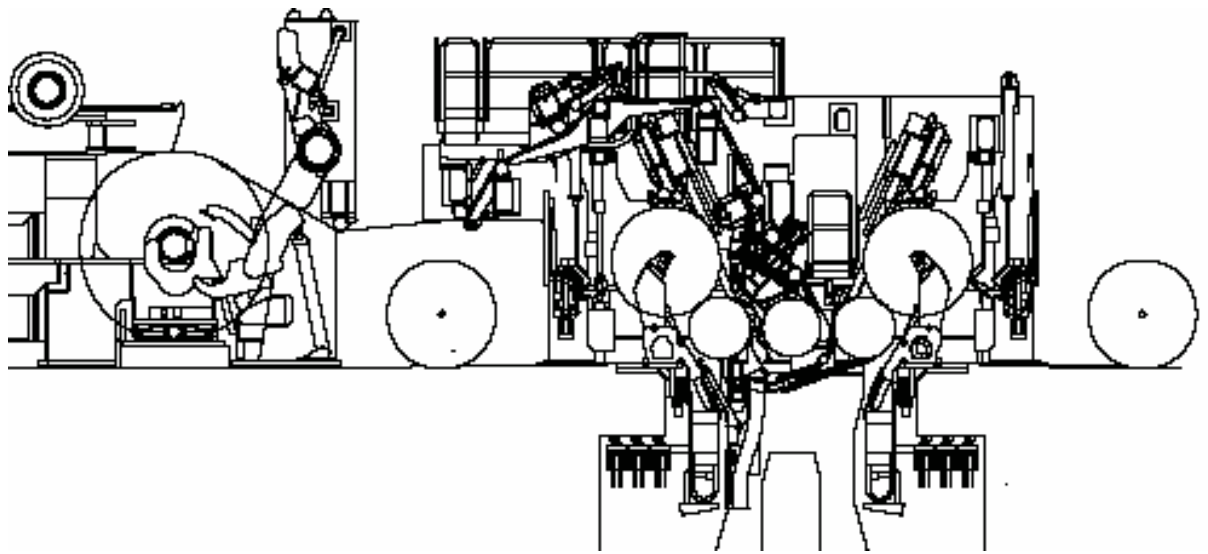


Figure 5. JR 1000 E multistation winder [2]

### 2.3.1 Rider rolls

Multistation winder allows rider roll load be specifically for each roll, this solves the problem of rider roll load unevenness encountered in two drum winders. Rider roll is only used for wider rolls: it could be used as roll width is over 940 mm, but usually rider rolls are used when roll width exceeds 1200 mm.

The function of rider roll also differs of what it is two drum winder. In multistation winder rider roll function is to support the core by creating supporting nip load. Without rider rolls nip load would be produced only by force applied to core ends by loading arms. This would cause great stress for core if roll width is high. Rider rolls are applied only in early part of winding to prevent bending of the core. When the diameter of roll is around 300 mm rider rolls are lifted as roll is strong enough to take stress only from core ends. As the diameter of roll increases also the nip load caused by rolls own weight increases, this reduces amount of force applied to core end.



Figure 6. Conventional rider roll unit

There are two types of rider rolls used in multistation winders: hard rider rolls and belted rider rolls. Hard rider rolls are older design and are without motor drive, in contrary belted rider rolls have motor drives. Use of hard rider rolls is only limited to supporting roll core.

Belted rider rolls allow higher rider roll loads than hard ones, this is possible through larger area in contact with roll surface. Although their main profit is applying additional torque in case of tighter winding is needed. [14]

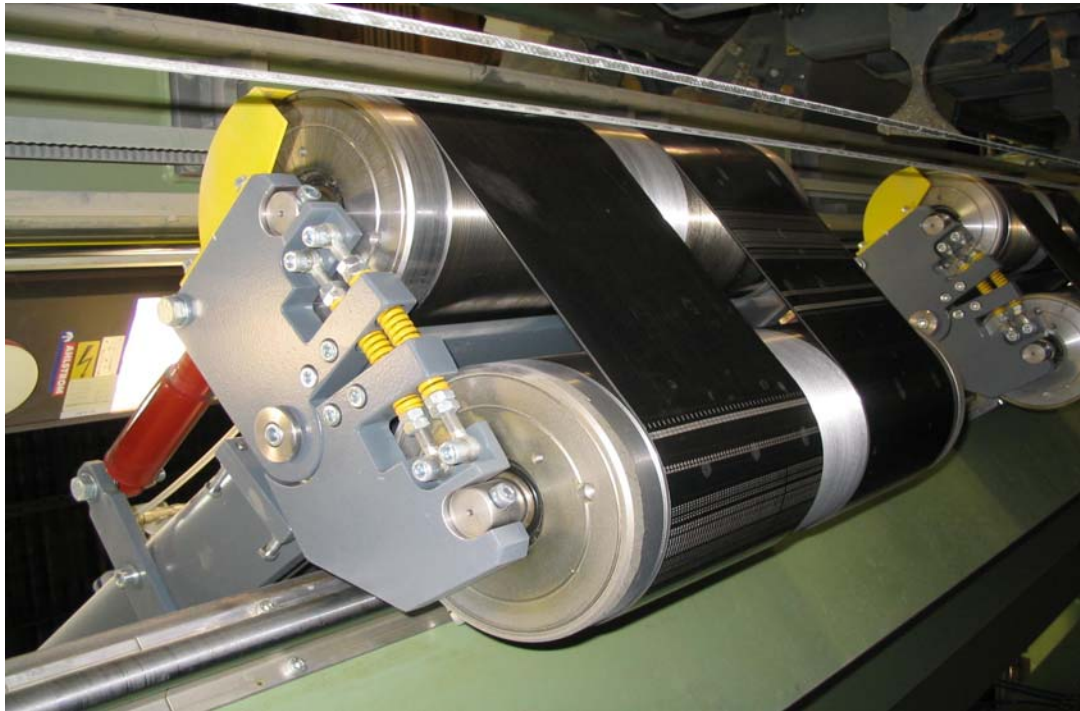


Figure 7. Belted rider roll unit

### 2.3.2 Modernisation

PL3 is a multistation winder. For this piece of equipment larger rebuild was done. Hard roll covers of winder were replaced with compliant roll covers. Soft roll covers makes possible to use higher nip loads without marking. Hard rider rolls were replaced with belted rider rolls, this investment adds driven rider roll support to winder. With these investments mill was able to solve their loose roll bottom problem and it allows also higher winding speeds

Soft roll covers make also possible to run with higher speeds without dishing problem. Additional benefit is reduced noise during winding.



### 3.Measuring methods

#### 3.1 *Tapio RQP roll hardness tester*

Tapio roll hardness measuring device is used measuring roll surface hardness. The occasions of use are fairly similar to situations where Schmidt hammer is often used. Tapio device offers better comfort of use as it automatically produces curve and values of measurement. The device is attached to tablet-PC so results can be easily stored and evaluated in electronically. [17]

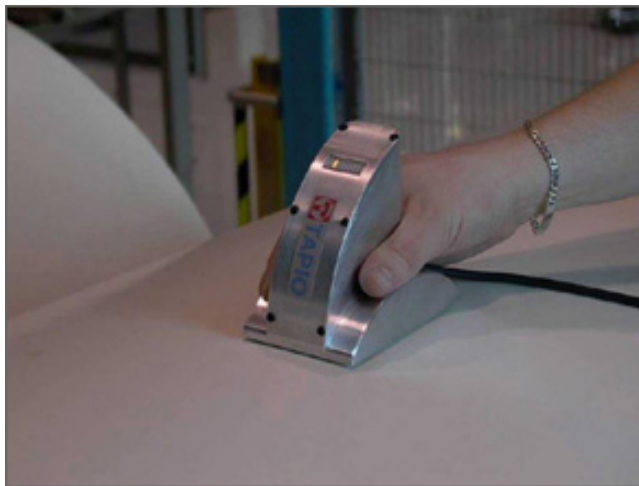


Figure 8. Tapio RQP [17]

The actual measuring is carried out by moving sensor on the surface of roll. When sensor is moved it hits roll surface and measures deceleration of head hitting to roll surface ten times per second. It also measures covered distance which enables better evaluation of results, compared to Schmidt hammer where operator has to determine measurement places. Also it is easier to get more results than with Schmidt hammer as Tapio RQP device measures roll hardness values in space of few centimetres or more often depending of speed of measurement. The results are given as deceleration caused by roll surface. The higher is the deceleration the harder is roll surface.

In this thesis work I also tried to use this measuring device to get results from roll tightness. Measurements were made from customer roll sides. This isn't purpose for

which this equipment has been made for, but the lack of better equipment for measuring roll tightness led me to use this measurement method alongside Smith needle.

### **3.2 Schmidt hammer**

Schmidt Hammer-test is used to determine hardness of roll surface. The device is used for same purpose as Tapio measurement device presented before in paper industry. Actually Schmidt hammer is developed for measuring hardness of concrete, but it has proved itself as a useful equipment also in paper industry.

Measuring is made by pushing Schmidt hammer in to roll surface, this compresses spring in device. As pushing force is hard enough, spring is released and piston hits to roll surface and bounces back. The magnitude of bounce is measured. This measuring method doesn't harm the roll. [8,10]

### **3.3 Smith needle**

Smith- Needle is a manual measuring device used to determine how tight roll is. Measuring procedure begins with marking diameter distances to roll side. Then needle is pushed in roll from the side and value for force needed to penetrate roll side is readable from the measuring device. The result is combination of friction and force pushing paper layers together. There are different types of needles used for different paper grades.

Problem with Smith needle measurement is that needle may damage roll, so measurement is alongside Cameron gap test more expensive to make than other test that were used. Another problem was that Smith needle wasn't available for use in all but few occasions, this limited the value of Smith needle measurements in my thesis work. [8]

### **3.4 Pull tab -test**

Pull-Tab test is measuring roll bottom tightness values. Measuring procedure begins with cleaning metal slip and placing it inside folded cigarette paper. This paper is then taped to core so that about 1 cm is left outside core. Once the roll is reeled and ejected from the winder, metal slip is pulled out from the roll by using specific measuring device which measures force needed to pull slip out. This force indicates how tightly inner paper layers at roll bottom are wound around the core. Problems with this measurement are metal slips that quite often break as you are pulling them out.

Executing this test is far easier on multistation winder than on two drum winder. The reason behind this is different layout of customer rolls. In Two drum winder all rolls are laid side by side so that core ends contact with each other damaging fragile metal slips used in this measurements, which reduces amount of successful measurements on two drum winder. Practically it is only possible to do pull tab test only for edge rolls, which in case of two drum winder do not give very reliable results because of possibly uneven rider roll load. In multistation winder success rate is higher due to different design in which roll is not in contact with other rolls and nip load is more uniform in each roll.

### **3.5 Cameron Gap**

Cameron gap test is used to evaluate roll structure. The test procedure begins with measuring roll diameter and marking radius every 50 mm. Then in space of 50 mm following procedure is carried out: One paper layer is cut using sharp knife, making sure that only one paper layer is cut. After this cut paper ends are pulled back together as near as possible without producing tension and remaining gap is measured. Stretch can be calculated from this gap and roll diameter. [8]

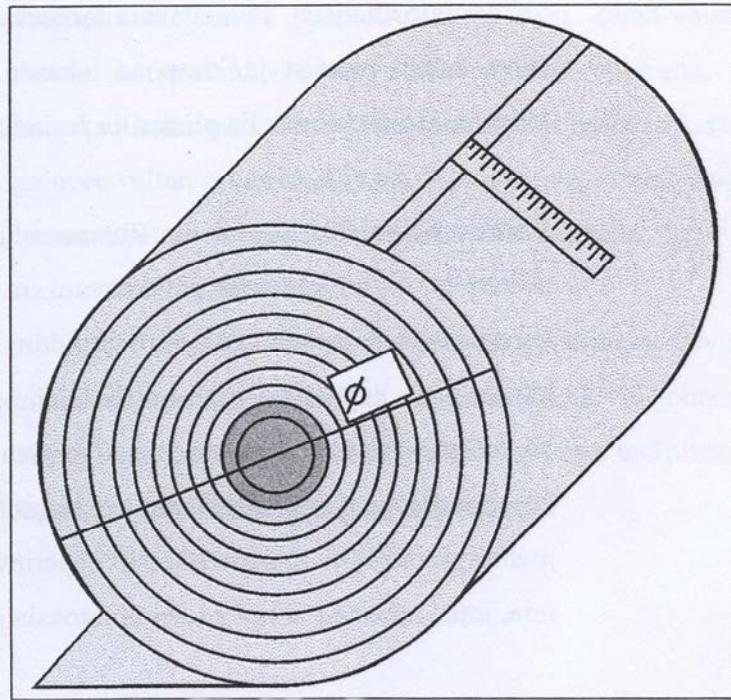


Figure 9. Cameron Gap test [10]

## 4. Experimental part

In Experimental part some abbreviations are used, especially in tables:

- AV stands for average
- HP means front end of machine viewed from control room
- KP means farther end of machine viewed from control room

### 4.1 PL3

The reason behind investment done for PL3 was occurring loose bottom problem on customer reels. Trial runs were carried out in order to solve problem by modernising winders with soft roll covers and belted rider rolls. Preliminary tests for investment were carried out at Metso Järvenpää technology center.

#### **4.1.1 Steel Cover**

First measurements were made for hard roll covers and conventional rider roll unit. For each trial run pull tab test was made and also dishing was measured. Pull tab test is useful for determining roll bottom tightness

Drive values were mainly the same as in normal production situation, except lower web tension value. Lower web tension was used in order to simulate situation in edge rolls, that is the position where dishing most usually occurs.

In these measurements there are some

##### **Drive values:**

Nip Load 3300 N/m

Rider roll load 2000 N/m, relieved at diameter 398 mm.

Winding speed 2000 m/min

Tension:

GL 39        380 N/m

GL 57        430 N/m

GB 60        430 N/m

GB 80        450 N/m

**Trial Runs:**

##### **Run 1 GB 80**

Table 1. Measurements [15]

Pull-tab	HP	KP	Average
	55	56	<b>55,5</b>
Dishing	1,5 mm		

## Run 2 GB 60

Table 2. Measurements [15]

Pull-tab	HP	KP	Average
	27/50	37/41	<b>38,75</b>
Dishing	4 mm		

## Run 3 GL 57

Table 3. Measurements [15]

Pull-tab	HP	KP	Average
	28/33	45/63	<b>42,25</b>
Dishing	2 mm		

## Run 4 GL 39.

Table 4. Measurements [15]

Pull-tab	HP	KP	Average
	56/36	49/39	<b>45</b>
Dishing	0 mm		

## Run 5 GB 80

The roll is the same which was used in run 1. Purpose of this run was to build up more dishing due to higher winding speed. Also effect of moment on bottom tightness was studied.

**Drive values:**

Drive speed 2500 m/min

Web tension 500 N/m

Nip load at the beginning 5000 N/m, Ø. 600 mm 3300 N/m

Web tension 550 N/m, roaming tension 100 %

At diameter 1000 mm dishing was so severe that roll touched loading arm, which means dishing was more than 10 mm.

Table 5. Measurements [15]

Pull-tab	HP	KP	Average
	109/76	75/83	<b>85,75</b>
Dishing	>10 mm		

At run five roll bottom tightness was improved due to higher nip load and especially due to full web tension used through whole winding, instead of lower tension used for crawling speed.

#### ***4.1.2 Soft roll Cover***

Tests with soft roll cover and belted rider rolls were carried out like with hard roll cover. Exception was that higher nip load and rider roll load were used.

**Drive values:**

Nip Load 10000 N/m

Rider roll load 7000 N/m, relieved at diameter of 398 mm.

Winding speed 2000 m/min

Tension:

GL 39        380 N/m

GL 57        430 N/m

GB 60        430 N/m

GB 80        450 N/m

**Run 6 GB 80**

Table 6. Measurements [15]

Pull-tab	HP	KP	Average
	124/118	115/165	<b>130,50</b>
Dishing	0 mm		

**Run 7 GB 60**

Table 7. Measurements [15]

Pull-tab	HP	KP	Average
	142/143	-/120	<b>135</b>
Dishing	0 mm		



### Run 8 GL 57

Table 8. Measurements [15]

Pull-tab	HP	KP	Average
	127/120	160/109	<b>129</b>
Dishing	0 mm		

### Run 9 GL 39

Table 9. Measurements [15]

Pull-tab	HP	KP	Average
	160/167	123/117	<b>141,75</b>
Dishing	0 mm		

### Run 10 GB 80

Roll was the same used in run 6.

Speed 2500 m/min

Tension 550 N/m, roaming tension 100 %

Other values the same as in trial 6.

Table 10. Measurements [15]

Pull-tab	HP	KP	Average
	170/176	202/174	<b>180,50</b>
Dishing	0 mm		

## Conclusions

From these results it can be seen that soft roll cover tightened roll bottoms significantly. From trial runs 5 and 10 can be seen that full web tension right from the start especially when combined with higher nip load result high roll bottom tightness values. Dishing wasn't an issue with soft cover, while it was limiting drive speed with hard roll cover.

Table 11. Summary of trial run measurements [15]

Grade	Drive Values	Bottom Tightness		Dishing	
		steel cover	soft cover	steel cover	soft cover
GB 80	normal	56	131	1,5 mm	0 mm
GB 60	normal	39	135	4 mm	0 mm
GL 57	normal	43	129	2 mm	0 mm
GL 39	normal	45	142	0 mm	0 mm
GB 80	Web tension 550 N/m (soft), 500 N/m (hard) Drive speed 2500 m/min	86	181	>10 mm	0 mm

### 4.1.3 Trial Runs After Modernisation

After modernisation had been carried out performance was tested with trial runs. Recipes were altered by changing nip load and also by increasing production speed higher than speed used in normal production situation. Unfortunately for many measurements there are not so good references from time prior to modernisation due to lack of measuring equipment. On the other hand test runs carried out in Järvenpää give good idea of real production situation.

#### 4.1.3.1 Smith needle test

Roll tightness values were measured with Smith needle measurement device. There is different needles used in this device depending of paper grade, but A-needle was used in test made for this thesis work.

From roll Tightness Measurements it was possible to see that increasing nip load from 3500 N/m to 5500 N/m increased roll tightness. Further increasing of nip load to 7500 N/m did not lead to large increase in tightness value. The difference in tightness values at 5500 N/m and 7500 N/m is insignificant. In the other hand quality wise there was no need to increase roll tightness values from existing figures achieved at previously used nip load of 3500 N/m

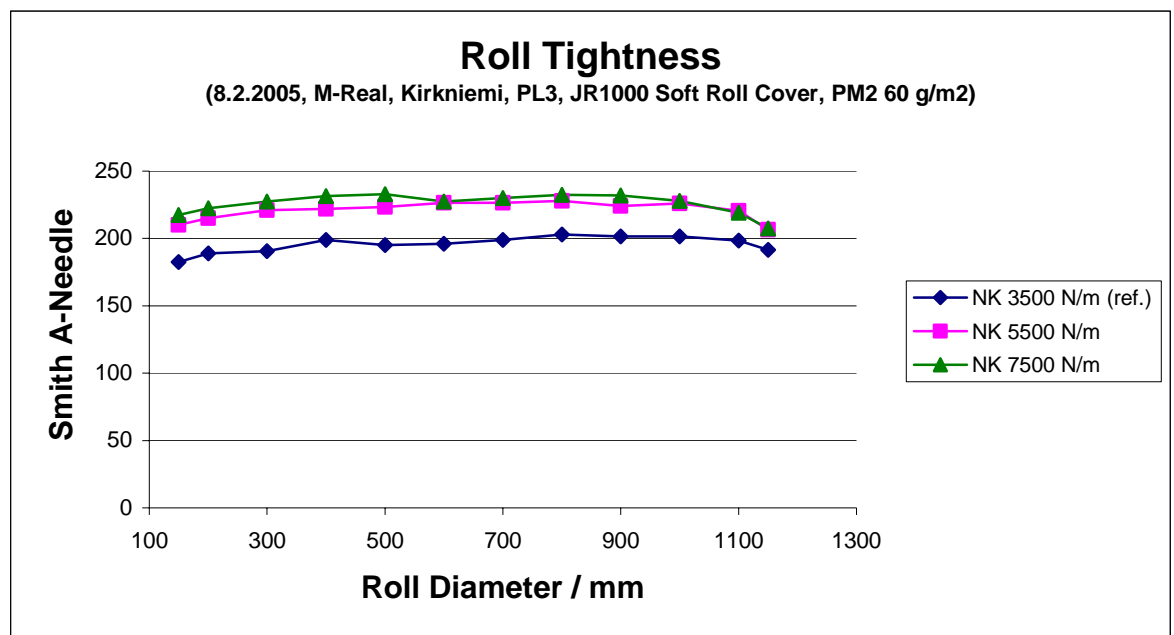


Figure 10. Smith needle tests after modernisation

#### 4.1.3.2 Pull tab test

Roll bottom tightness values were measured with pull tab tests. Increasing roll bottom tightness was one of the main reasons behind the investment decision, so it was essential to achieve improvement in this value. Unfortunately no pull tab test were made on actual production machine before modernisation, so we had to rely on measurements done in Järvenpää with combination of hard roll cover and

conventional rider roll. Another reason behind the lack of values before modernisation was that those were considered to be more or less insignificant as same modernisation was done to another identical winder in the same mill only one year ago.

Table 12. Pull tab tests after modernisation

3500 N/m	Pull-tab	HP	KP	<b>AV.</b>
	station 2	154	139	<b>147</b>
	station 4	88	84	<b>86</b>
	station 3	114	98	<b>106</b>
	<b>AV.</b>			<b>113</b>
5500 N/m	Pull-tab	HP	KP	<b>AV.</b>
	station 2	173	173	<b>173</b>
	station 4	131	123	<b>127</b>
	station 3	138	150	<b>144</b>
	<b>AV.</b>			<b>148</b>
7500 N/m	Pull-tab	HP	KP	<b>AV.</b>
	station 2	153	180	<b>167</b>
	station 4	137	137	<b>137</b>
	station 3	163	Slip broken	<b>163</b>
	<b>AV.</b>			<b>156</b>

From pull tab measurements can be seen the influence of increased nip load to roll bottom tightness. Like in the roll tightness values measured with Smith needle the difference between niploads 3500 N/m and 5500 N/m is more significant than the further addition to 7500 N/m.

### 4.1.3.3 Tapio RQP Measurements

table 13. Tapio RQP measurements before and after modernisation

Parent reel no.		roll 1	roll 2	roll 3	roll 4	roll 5	roll 6	roll 7	AV.
5034	Before	76,7	71,7	73,3	75,0	70,8	75,7		73,9
5039	Before	67,7	66,8	71,2	70,8	75,8	82,1		72,4
5146	After	74,0	74,3	76,2	84,0	77,6	76,4	80,6	77,6
5145	After	77,9	78,2	77,9	78,4	76,9	77,6	79,1	78,0

In Measurements done with Tapio RQP is shown small increase in roll surface hardness value. In measurements it was also possible to see how winder manages to even up variation in parent reel. The increase of roll surface hardness value has not been goal of investment, but as seen in Cameron gap tests presented later in this thesis work surface tightness isn't an issue on PL3.

## 4.2 PL1

### 4.2.1 Cameron Gap tests

Cameron gap test was carried out to one roll before the modernisation was made. Further Cameron Gap measurements were done after modernisation in order to find reason to roll quality issues that occurred after modernisation. The difference in execution of these measurements was that before modernisation the test was done to the whole roll and after the measurement was done only to roll surface. Reasons behind that was the high price of doing test to whole roll and also because it is very time consuming to do test for whole roll.

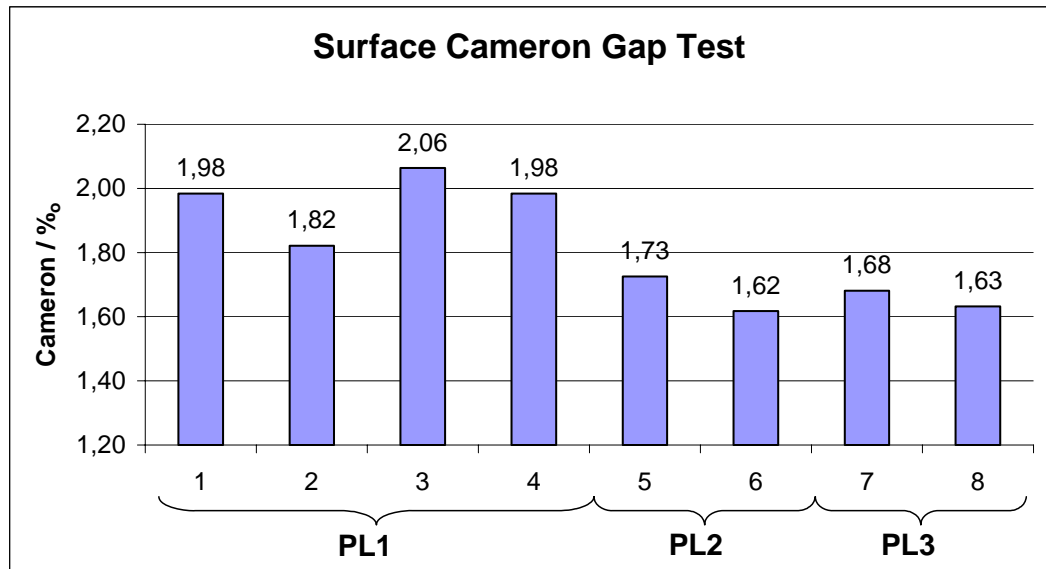


figure 12. Cameron gap test on paper surface [9]

Cameron gap test made to roll surface shows one of the major problems encountered when winding LWC paper with two drum winder: Large customer roll diameter results high nip load and which causes roll surface becomes too tight on PL1. This problem is most severe with large diameter rolls. Cameron gap values for multistation winders PL2 and PL3 are in acceptable level. According to TAPPI standards Cameron gap values should not exceed 2.1-2.3 ‰. The Values of rolls from PL1 are near this level.

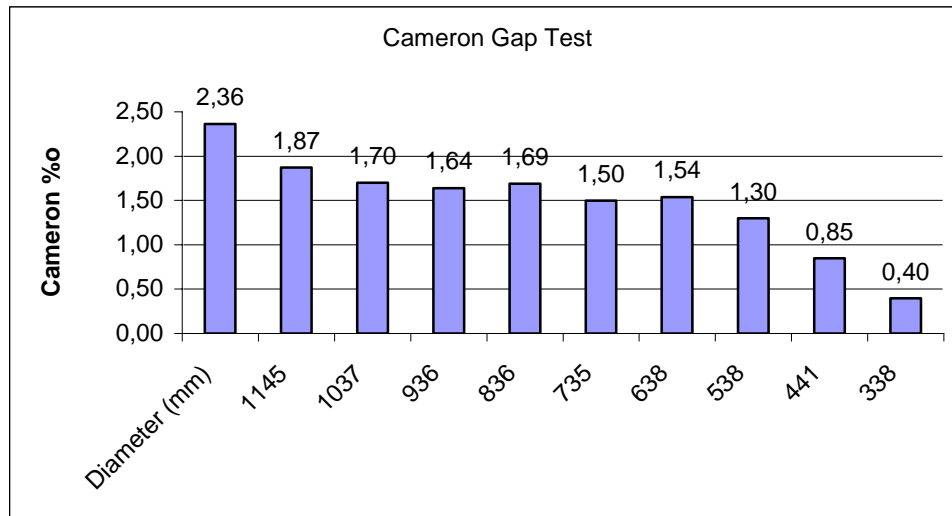


Figure 13. Cameron gap test for whole roll before modernisation

Cameron gap test made to whole roll before modernisation shows that surface tension has been high also before modernisation. Not too big conclusions should be made from only one measurement, but it is notable that value on surface is already exceeding recommended values by TAPPI despite roll diameter is only 1145 mm. It presumably means that surface of roll is too tight on maximum diameter around 1250 mm which is production maximum on PL1.

Also in measurement for whole roll can be seen the profile of roll as a function of diameter. There it can be seen that roll tightness seems to be quite well controlled during winding except situation in the end when weight of the roll becomes too high. The lower values in the bottom of the roll may be as low as they are partly because of uneven rider roll load as measured roll was edge roll from the set. Other problem is decreasing measurement accuracy as roll diameter becomes smaller, which makes results more unreliable on the roll bottom.

#### 4.2.2 Tapio RQP Measurements

Table 14. Tapio RQP measurement on PL1 before and after modernisation.

	reel	g/m <sup>2</sup>	roll 1	roll 2	roll 3	roll 4	roll 5	roll 6	roll 7	Average
before	606	45	71,0	66,7	70,3	72,4	74,0	69,8	69,4	70,5
before	605	45	70,7	64,9	72,0	74,4	73,2	67,9	na.	70,5
after	744	54	78,7	80,6	68,8	61,5	82,4	72,0	68,4	73,2
after	745	54	67,2	76,2	77,0	70,3	80,3	70,1	70,9	73,1

Tapio RQP measurements do not have big difference between situation before modernisation and after modernisation. This result is expected as this measurement indicates roll surface hardness value. In investment only rider roll was replaced so it had very small or even nonexistent influence to TAPIO RQP results. The most likely reason behind the difference on situation before and after modernisation is different paper grade.

#### ***4.2.3 Problems after investment***

After installing soft rider roll unit customer roll quality problems were encountered. First visible issue was dishing problem in edge rolls of set. Unlike in normal dishing situation when dishing occurs in roll surface, in this case web had moved in the beginning of winding. This problem could be partially solved by adjusting lead roll placed before the actual web spreading rolls. Lead roll was lowered. This lead roll is usually not used to control web as web steering is usually handled with web spreaders. The problem with this adjustment was problems on startup of first set with each parent reel.

In literature this problem is called acceleration offset. It means paper web moving sideways when machine speed is increased or decreased. In this phenomenon web movement is especially severe at the start and the bottom of the ramps, which was the case also on PL1. The cure or at least improvement for this issue is to reduce the roller misalignment and other geometrical problems, which might have been the case on adjusting lead roll. [7,11]

Another problem was high roll surface tightness value. Problem is best visible in Cameron gap test. In order to cope with this problem web tension on large diameter rolls was reduced, but the main issue is winder type which is not best suitable for this paper grade.



## 5. Conclusions

During my thesis work limitations of two drum winder became clear. LWC paper grade is not suitable to two drum winder. Investment on rider roll can not help fundamental problem of uncontrollable increase of nip load. This problem is hard or even impossible to solve with drive values. Unfortunately new rider roll unit also failed to achieve improvement on dishing issue. Paper profile is significant factor in dishing problem.

Modernisation of PL3 can be considered successful. Desired roll bottom tightness was achieved. Roll bottom tightness was considered to be worst handicap of winder. Winding speed can be increased as soft roll covers reduce dishing problem at high winding speed. In current situation PL3 three is well suitable for demands of winding LWC paper.

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